PCT / CA 00/01183

Office de la propriété intellectuelle du Canada

Un organisme d'Industrie Canada

Canadian Intellectual Property Office

An Agency of Industry Canada

23 OCT 2000 (23.10.00)

10/089100

REC'D 02 NOV 2000

WIPO PCT

Bureau canadien des brevets

Certification

Canadian Patent Office

Certification

La présente atteste que les documents ci-joints, dont la liste figure ci-dessous, sont des copies authentiques des documents déposés au Bureau des brevets.

This is to certify that the documents attached hereto and identified below are true copies of the documents on file in the Patent Office.

Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,286,883**, on October 15, 1999, by **FANTOM TECHNOLOGIES INC.**, assignee of Wayne Ernest Conrad, for "Method for Reducing the Power Consumption of an Electric Motor".

CA00/1183 4

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

L. Régimbal

Agent certificateur/Certifying Officer

October 23, 2000

Date

Canada

(CIPO 68)

OPIC CIPO

ABSTRACT

A method and apparatus are provided for controlling the electrical power applied to an electric motor. The method is based on modulating the electric power supply with a pulse train. Pulses of the pulse train have characteristics of frequency, voltage and pulse width. At least two of these are modified or modulating, in accordance with an algorithm, to reduce the power supply to the motor or otherwise to cause the motor to run more efficiently.

CA 02286883 1999-10-15

B&P File No. 5582-836

BERESKIN & PARR

CANADA

<u>Title</u>: METHOD FOR REDUCING THE POWER CONSUMPTION OF AN ELECTRIC MOTOR

<u>Inventor</u>: Wayne Ernest Conrad

Title: METHOD FOR REDUCING THE POWER CONSUMPTION OF AN ELECTRIC MOTOR

FIELD OF THE INVENTION

This invention relates to electric motors. This invention more particularly is concerned with the method and apparatus for improving the power consumption of an electric motor. Additionally, this invention has general applicability to electrical power consuming devices or circuits, having characteristics outlined below.

BACKGROUND OF THE INVENTION

There are many applications today in which electric motors are employed. The energy consumption of motors for pumping gases and liquids accounts for over one-quarter of all electricity consumed in the world today. There are known a number of techniques, employing pulse width modulation, to control the power consumption of motors; such techniques have had modest success and generally are provided to control motor power or speed with little or no regard for improving motor efficiency.

The intention of the present invention is to significantly reduce the power consumption of electric motors, particularly in such applications as the movement of air and pumping of liquids. Research by the inventors has found that these types of electromechanical assemblies have a natural resonance. Additionally, it has been found that when the electrical signal or power supplied to the device is conditioned, so as to provide energy in synchronism with natural resonant frequencies of the motor and associated equipment, the power required to produce the desired work is significantly reduced.

Additionally, it is believed this invention has general applicability to any electrical power consuming circuit or device which shows similar characteristics. That is, it is applicable to any device which shows some resonant characteristics, and where providing the power

signal as a pulse train with suitable characteristics of voltage, frequency and pulse width, can improve the efficiency; in effect energy coupling or transfer from the electrical power supply to the circuit or device is enhanced. This in turn can reduce the power energy required to deliver the desired work.

SUMMARY OF THE INVENTION

The present invention is based on the realization that the excitation of an electric motor, either a DC or AC motor, can be improved by providing the signal as a pulse train, with the characteristics of voltage, frequency and pulse width, modulated to optimize a power delivered. This can be applied to either AC or DC motors.

In accordance with the present invention, there is provided a method of controlling the electrical power applied to an electric motor, the method comprising the steps of:

(1) providing an electric power supply;

(2) modulating the electrical power supply with a pulse train to provide a series of pulses;

(3) selecting at least one parameter from the group comprising frequency, voltage and pulse width, to modulate the characteristics of the pulse train; and

(4) supplying the pulse train to the electric motor to supply power to the electric motor.

The method can include: selecting a combination of pulse width and voltage to modulate the power supply to the motor; or a combination of frequency and voltage to modify the power supplied to the motor; or a combination of frequency and pulse width to modulate the power supplied to the motor; or a combination of frequency, pulse width and voltage, to modulate the power supplied to the motor.

Either an alternating current power supply or a direct current power supply can be provided.

The method preferably includes carrying out a series of tests

by providing the pulse train at a plurality of different values of one parameter of the pulse train, selectively modifying a second parameter of the pulse train, and noting variation of a motor characteristic.

Another aspect of the present invention provides an apparatus, enabling control of the power consumption of a motor, the apparatus comprising:

an input for receiving an electric power supply signal;
an electronic control unit connected to the input; and
an electric motor connected to the electronic control unit.

Preferably, the electronic control unit modulates the electrical power supply signal with a pulse train and modulates at least two of the pulse width, the voltage and the frequency of the pulse train.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

For a better understanding of the present invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example, to the accompanying drawing, which shows a preferred embodiment of the present invention, and in which:

Figure 1 is a schematic view of an apparatus and an electric motor in accordance with the present invention; and

Figure 2 is a graph showing an exemplary pulse train over one period.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a voltage source 1, which can provide either AC or DC power, and connected to an electronic control unit 2 by connections or wires 3, 4. The electronic control unit 2 in turn is connected to the actual electric motor 5, by means of wires 6 and 7.

The electronic control unit 2 receives either an AC or DC power supply signal over the wires 3, 4.This is modified or conditioned by modulating the signal with a pulse train. The unit 2 effectively modifies one or more of the characteristics of the pulses, namely pulse width,

voltage and frequency. This is done by modulating at least two and possibly three of these characteristics. Thus, the unit 2 could modify: the pulse width and voltage of the signal; the frequency and voltage of the signal; the frequency and pulse width of the signal; or the frequency, pulse width and voltage together. Whichever characteristic is not modulated, is set at a fixed value.

A basic premise of the invention is that for a motor, or indeed for other electrical systems, there is usually some sort of resonant effect between the power supply and the motor itself. This resonant effect is not properly understood. However, the inventors have realized that it is not necessary to fully understand this behaviour, for example by providing some sort of mathematical model. Rather, it is sufficient to carry out a series of tests or experiments to establish the characteristics that give optimum performance.

In order to optimize the performance of a given motor for a given load, a series of variables are sequentially altered and the power consumed is measured. Initially, the normal running voltage for the motor is applied and the frequency is increased in 10% increments. At each frequency increment, the pulse width of the signal is reduced until either the power consumed increases by 25% or the motor r.p.m. is altered by more than 20%. This procedure is repeated for 100%, 95%, 90%, 85%, 80%, 75%, 70%, 65%, 60%, 55%, 50%, 45% and 40% of the normal running voltage. This data is then topographically mapped and an algorithm to optimize the motor is selected so as to reduce the power consumed by modulating the applied voltage, applied frequency and pulse width of the signal.

The pulse train comprises a set cycle of pulses, for example, a plurality of pulses that may be of the order of 10 pulses or more longer. Pulses within the cycle can vary, in terms of their pulse width and pulse height, as detailed below in relation to Figure 2. This cycle is repeated continuously, to generate the pulse train.

This invention is believed to have particular applicability to

vacuum cleaners. As such, a motor for a vacuum cleaner is attached to a fan, for drawing air through the vacuum cleaner, so as to produce the desired vacuum effect. What the inventor has realized is that the individual blades of a fan commonly throw off a series of vortices. In effect, a boundary layer continually builds up, separates and collapses on one side of each blade. This leads to much wasted energy.

The inventor has discovered that if the signal supplied to the motor is configured so as to cause acceleration just prior to collapse or delamination of the boundary layer, and to decelerate just after delamination, then the boundary layer does not in fact completely collapse, but instead simply reduces or thins down. In effect, this reduces the vortex energy thrown off from the blade, and hence significantly reduces energy losses. Accordingly, the algorithm for the pulse train for a vacuum cleaner should be developed, with this in mind. This is done simply by running a series of tests or experiments on a complete vacuum cleaner, which will allow for any effects which will alter the power consumption of the motor.

Figure 2 shows exemplary pulse wave forms over a period 20. Within this period 20, there are 5 individual pulses, labelled 21, 22, 23, 24 and 25. Following each pulse, there is a respective pulse interval, labelled at 21a, 22a, 23a, 24a and 25a. In this example, these intervals have the parameters given in the following table and shown in the drawing.

TABLE 1

Pulse Number	Pulse Voltage	Pulse Duration	Pulse Interval
21	1.3	0.7	4 ms
22	1.4	0.8	5 ms
23	1.5	0.9	6 ms
24	1.6	0.1	7 ms
25	1.9	0.1	10 ms

As this table shows, within the period 20, all the parameters of the pulses, namely frequency (i.e. inverse of the pulse interval), pulse width or duration, and pulse height (voltage) are varied. This gives a distinct pulse profile for the period, and this is repeated in following periods. In general, depending on the particular application, it may not be necessary to vary all three parameters, and it may be sufficient to vary just two of them, or even just one of them, with the other(s) being kept constant. Additionally, it will be understood that the absolute magnitude of each of these parameters can vary greatly depending upon the actual application. Also, a variety of pulse profiles can be used.

It is to be appreciated that the pulse profile detailed above was developed primarily for a battery charge/discharge aspect of the present invention, the subject of separate simultaneously filed applications by the same inventor. For use with an electric motor suitable pulse train characteristics can be selected.

CLAIMS:

1. A method of controlling the electrical power applied to an electric motor, the method comprising the steps of:

(1) providing an electric power supply;

(2) modulating the electrical power supply with a pulse train to provide a series of pulses;

(3) selecting at least one parameter from the group comprising frequency, voltage and pulse width, to modulate the characteristics of the pulse train; and

(4) supplying the pulse train to the electric motor to supply power to the electric motor.

2. A method as claimed in claim 1, which includes selecting a combination of pulse width and voltage to modulate the power supply to the motor.

3. A method as claimed in claim 1, which includes selecting a combination of frequency and voltage to modify the power supplied to the motor.

4. A method as claimed in claim 1, which includes selecting a combination of frequency and pulse width to modulate the power supplied to the motor.

5. A method as claimed in claim 1, which includes selecting a combination of frequency, pulse width and voltage, to modulate the power supplied to the motor.

6. A method as claimed in any preceding claim, which includes providing an alternating current power supply.

7. A method as claimed in any one of claims 1 to 5, which includes providing a direct current power supply.

8. A method as claimed in any preceding claim, which includes carrying out a series of tests by providing the pulse train at a plurality of different values of one parameter of the pulse train, selectively modifying a second parameter of the pulse train, and noting variation of a motor characteristic.

9. A method as claimed in claim 8, which includes noting variation of at least one of: power consumed by the motor; and motor r.p.m.

10. An apparatus, enabling control of the power consumption of a motor, the apparatus comprising:

an input for receiving an electric power supply signal;

an electronic control unit connected to the input; and

an electric motor connected to the electronic control unit.

11. An apparatus as claimed in claim 10, wherein the electronic control unit modulates the electrical power supply signal with a pulse train and modulates at least two of the pulse width, the voltage and the frequency of the pulse train.

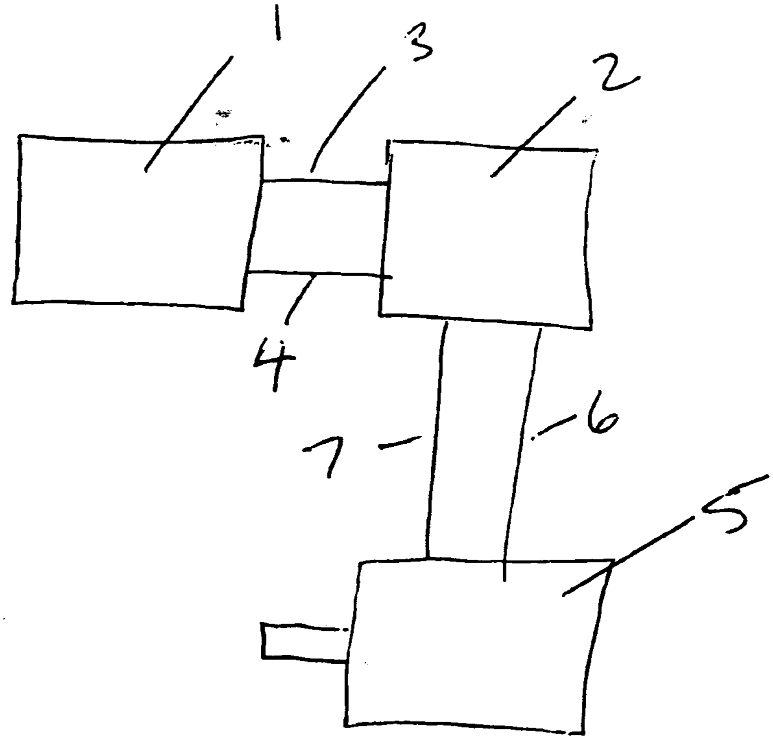

Figure 1

Oct 9, 1999
3 of 3

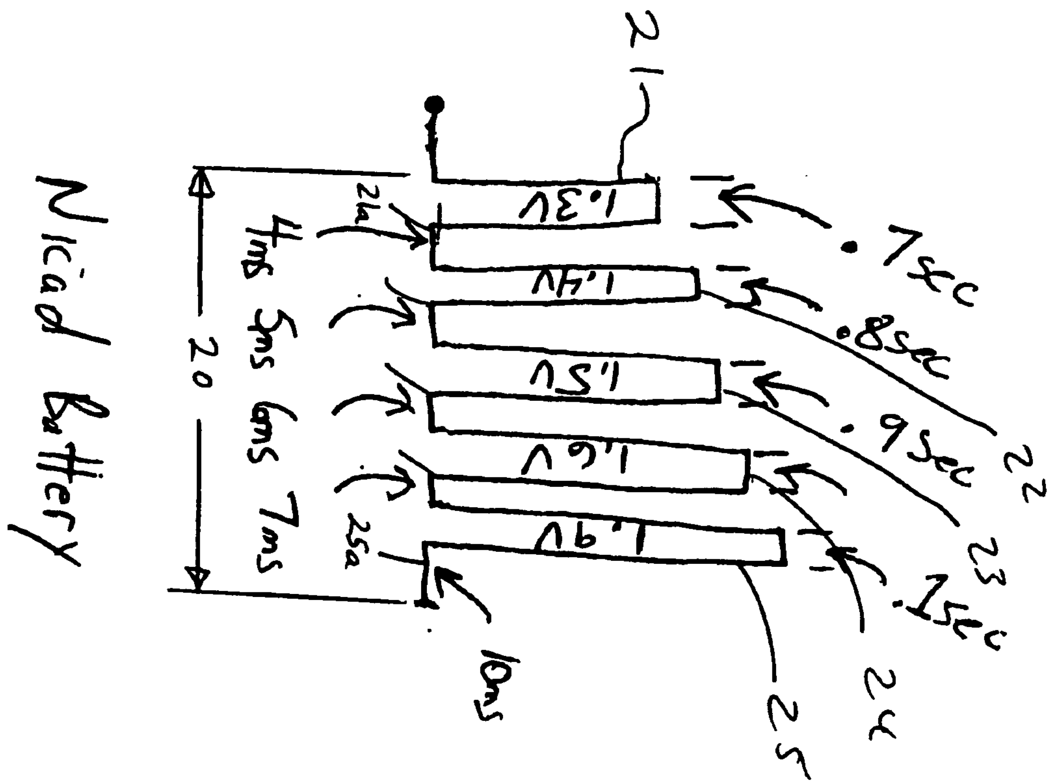
Nicad Battery
20
21
21a
1.3V
1.4V
1.5V
1.6V
1.9V
4ms 5ms 6ms 7ms
25a
10ms
.7sec
.8sec
.9sec
.1sec
22
23
24
25

Figure 2.